PERFORMANCE ANALYSIS OF BIT ERROR RATE PARAMETER USING WAVELET BASED OFDM ON LTE STANDARD OVER DIFFERENT CHANNELS

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ABSTRACT
In 4th Generation Long Term Evolution (LTE), The two key techniques which are employed are Orthogonal Frequency Division Multiplexing (OFDM) and Multiple Input and Multiple Output (MIMO). The idea behind using OFDM technique is to use multiple orthogonal carriers to provide higher level of spectral efficiency. Cyclic Prefix (CP) needs to be used in OFDM to avoid Inter Carrier interference (ICI) and Inter Symbol Interference (ISI) because of loss of orthogonality between carriers. The use of cyclic prefix in OFDM increases available bandwidth. Alternative to the above described system, Wavelet based OFDM is yielding better performance in terms of Bit Error Rate and Spectral Efficiency. In this paper, Wavelet based analysis in LTE system is carried out for different channels (AWGN, Rayleigh) and for different modulation schemes (16QAM, 64QAM) and the performance is compared with conventional OFDM system.

Key words: LTE; OFDM; MIMO; DFT; CP; ICI; ISI; BER.

I. INTRODUCTION
In wireless communications field, there is a rising demand for high performance, high capacity and high data rate. Digitally techniques were adopted for these purposes. Orthogonal frequency division multiplexing (OFDM) is a multicarrier modulation technique which divides the available spectrum into a number of parallel subcarriers and each subcarrier is then modulated by a low rate data stream at different carrier frequency. OFDM offers immunity, high spectral efficiency to the multipath delay and low inter symbol interference (ISI). Cyclic Prefix (CP) is added to each symbol to mitigate the ISI (inter-symbol interference) caused by multipath wireless channel, and hence leads to spectral inefficiency. On the other hand, wavelet based modulation satisfies orthogonality criterion by orthogonal wavelet filter banks. We can have all the benefits of OFDM even if we replace traditional sinusoid carriers of the Fourier based OFDM with suitable wavelets. Wavelet based systems have been shown to have better immunity to impulse and narrowband noises than Fourier OFDM, also the interference power can to a large extent, be mitigated. Moreover, wavelet based OFDM doesn’t require any CP, hence increases spectral efficiency, does not produce the ripples, reduces complexity, leading to a better symbol rate, hence no power wastage for redundancy.

Few works have been proposed in the recent years that compares the performances of wavelet and FFT based OFDM systems focusing on effects of noise, error performances, and computational complexity, etc. It is indeed needed to analyse the wavelet based OFDM systems in some practical multiuser scenarios. In this work, the different channels are being considered to compare the BER performance of wavelet and FFT based OFDM. AWGN channel model is widely used in studying OFDM. In this model there is only linear addition of white noise with a constant spectral density and Gaussian distribution of amplitude. The model does not consider fading, frequency selectivity, interference etc. Although it is not much suitable for most of the terrestrial links yet being used for providing simple and controlled mathematical models to study the basic behaviour of a system in the absence of the above mentioned factors. In contrast to AWGN channel, in a multipath channel the transmitted signal reaches the receiver as a train of impulses. A multipath Rayleigh Fading channel considers the fading effects similar to an actual terrestrial channel. It is best suitable for tropospheric and ionospheric signal propagation and for signal propagation in urban environments in short when there is no line of sight between transmitter and receiver. This article also compares the performances of different wavelets and FFT based OFDM systems in different channels using different modulation techniques and through an extensive simulation it is shown that different wavelets outperforms the FFT based OFDM considering AWGN and Rayleigh channel. The
rest of this paper is organized as follows: A brief overview of FFT and wavelet based OFDM are discussed in Section 2. Simulation results are given in Section 3. Finally, Section 4 concludes the paper.

II. DFT BASED OFDM & WAVELET BASED OFDM

For typical OFDM system sinusoids of DFT type associate orthogonal basis perform set. Here orthogonal basis functions are the subcarriers utilized in OFDM. At the receiver the signals are combined to get the information transmitted. Much, fast Fourier remodel (FFT) and Inverse quick Fourier remodel (IFFT) are used for the implementation of the OFDM system as a result of less range of computations needed in FFT and IFFT. Fourier based Conventional OFDM system has been a popular choice for wireless transmission over a long time for its transmission performances which is shown in figure 1. In Fourier analysis we break up a signal into a set of an infinite sum of Sines and Cosines to exploit the Orthogonality relationship between them. On the other hand, using wavelet transform the signal is first decomposed by a low-pass (LP) and a high-pass (HP) filter. Half of the frequency components have been filtered out at filter outputs and hence can be down-sampled. During decomposition, the high pass filter will remove the frequencies below half of the highest frequency and low pass filter will remove frequencies that are above half of the highest frequency. The decomposition halves the time resolution because half of the samples are used to characterize the signal similarly frequency resolution will be doubled and this decomposition process will be repeated again for obtaining the wavelet coefficients of required level. Two types of coefficients are obtained through processing, first ones are called detailed coefficients obtained through high pass filter and second ones are called coarse approximations obtained through low pass filter related with scaling process. After passing the data through filters the decimation process will be performed. The whole procedure will continue until the required level is reached. In inverse discrete wavelet transform (IDWT), the reverse process of decomposition is performed. Here up sampling is performed first. Then the signal is passed through the filters. Thus obtained data is combined to obtain reconstructed data. Number of levels during reconstruction will be same as that of decomposition levels.

Wavelet rework could be a tool for analysis of the signal in time and frequency domain together. It’s a multi resolution analysis mechanism where the signal is completely transformed to different frequency elements for the analysis with explicit resolution matching to scale. Using any explicit sort of ripple filter the system will be designed in line with the necessity and additionally the multi resolution signal will be generated by the utilization of wavelets. By the utilization of varying ripple filter, one will style waveforms with selectable time/frequency partitioning for multi user application. Wavelets possess higher Orthogonality and have localization each in time and frequency domain and because of good Orthogonality wavelets area unit capable of reducing the power of the international intelligence agency and ICI, which ends from loss of Orthogonality.

In this article, Figure 1 shows the transmitter and receiver section which uses conventional FFT implementation of OFDM model. AWGN channel / Rayleigh channel is used for transmission and cyclic prefixing (CP)is used to avoid ICI and ISI. On the other hand, Wavelet based OFDM system uses IDWT and DWT at the place of IDFT and DFT which is shown in Figure 2. AWGN channel / Rayleigh channel is used for analysing the performance. Here cyclic prefixing is not used. In this system, all conventional encoding is done followed by interleaving then data is converted to decimal form and modulation is done next. After modulation the pilot insertion and sub carrier mapping is done. Next IDWT is performed on the data, which provides the orthogonality to the subcarriers. IDWT will convert time domain signal to the frequency domain. After passing through the channel on the signal, DWT will be performed and then pilot synchronization where the inserted pilots at the transmitter are removed then the demodulation is done. Demodulated data is converted to binary form and the de-interleaved and decoded to obtain the original data transmitted.

Wavelet based OFDM is very similar to the Fourier based OFDM. The only difference is that, the IFFT and FFT blocks are substituted by IDWT and DWT blocks respectively. In this analysis, The Haar wavelet and Coiflet wavelets are used to study BER curves. As Haar wavelet is concerned, it is a sequence of rescaled “square-shaped” functions which together form a wavelet family or basis. Wavelet analysis is similar to Fourier analysis in that it allows a target function over an interval to be represented in terms of an orthonormal basis.

On the other hand, Coiflets are discrete wavelets designed by Ingrid Daubechies, at the request of Ronald Coifman, to have scaling functions with vanishing moments. The wavelet is near symmetric, their wavelet functions have vanishing moments and scaling functions, and has been used in many applications using Calderón-Zygmund Operators. Hence is this approach, Wavelets such as Haar and Coiflet are used to compare the performance of BER in AWGN and Rayleigh channel. In both the OFDM systems, the modulation techniques used are 16QAM and 64 QAM.
III. SIMULATION RESULTS & DISCUSSION

In the simulation of DFT based OFDM and Wavelet based OFDM systems, the performance of both the systems are compared in terms of SNR(dB) Vs. Bit Error Rate (BER). By using MATLAB, performance characteristic of DFT based OFDM and wavelet based OFDM are obtained for various modulations such as 16QAM and 64QAM that are used for the LTE. The simulation is carried out for AWGN and Rayleigh channels. Wavelets used in the analysis are Haar and Coiflet wavelets.

For the purpose of simulation, signal to noise ratio (SNR) of different values are introduced through AWGN channel and Rayleigh channel. Averaging for a particular value of SNR for all the symbols is done and BER is obtained and same process is repeated for all the values of SNR and final BERs are obtained. From the simulation results shown below, Wavelet based OFDM proves to be the better competitor than the conventional DFT based OFDM system. Also, Coiflet wavelet yields better performance than Haar wavelet from the curves shown.
Fig. 1. BER performance of Haar, Coiflet and DFT based OFDM in AWGN Channel (16QAM)

Fig. 2. BER performance of Haar, Coiflet and DFT based OFDM in Rayleigh Channel (16QAM)
BER Performance of DFT, Haar, Coiflet in AWGN channel using (64QAM)

Fig. 3. BER performance of Haar, Coiflet and DFT based OFDM in AWGN Channel (64QAM)

BER Performance of DFT, Haar, Coiflet in Rayleigh channel using (64QAM)

Fig. 4. BER performance of Haar, Coiflet and DFT based OFDM in Rayleigh Channel (64QAM)
IV. CONCLUSION

In this paper, the performance of different wavelets based OFDM system under different channels using different modulation schemes were analysed and compared it with the performance of DFT based OFDM system. It is observed from the performance curves that the BER for Wavelet based systems are better than that of DFT based OFDM system. The Different modulation techniques such as 16QAM and 64QAM which are used in LTE are used in different channels such as AWGN and Rayleigh channel. Among the wavelets, the DWT-Coiflet is yielding better BER in 16QAM and 64QAM than Haar wavelet and DFT-OFDM under AWGN channel and Rayleigh channel.

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REFERENCES


